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Background

Diagnostic testing is common during emergency department visits. Little is understood about patient preferences for such testing. We hypothesized that a patient's willingness to undergo diagnostic testing is influenced by the potential benefit, risk, and personal cost.

Methods

We conducted a cross sectional survey among emergency department patients for diagnostic testing in 2 hypothetical scenarios: chest pain (CP) and mild traumatic brain injury (mTBI). Each scenario defined specific risks, benefits, and costs of testing. The odds of a participant desiring diagnostic testing were calculated using a series of nested multivariable logistic regression models.

Results

Participants opted for diagnostic testing 68.2% of the time, including 69.7% of CP and 66.7% of all mTBI scenarios. In the chest pain scenario, 81% of participants desired free testing versus 59% when it was associated with a $100 copay (difference: 22%; 95% CI 16 - 28%). Similarly, in the mTBI scenario, 73% of adult participants desired free testing versus 56% when charged a $100 copayment (difference 17%; 95% CI 11 - 24%). Benefit and risk had mixed effects across the scenarios. In fully adjusted models, the association between cost and desire for testing persisted in the CP (OR 0.33; 95% CI 0.23 - 0.47) and adult mTBI (OR 0.47; 95% 0.33 - 0.67) scenarios.

Conclusions

In this emergency department based study, patient preferences for diagnostic testing differed significantly across levels of risk, benefit, and cost of diagnostic testing. Cost was the strongest and most consistent factor associated with decreased desire for testing.

Introduction

The emergency department has emerged as a focal point for rapid access to advanced diagnostic testing and hospital admission. Currently, given the pervasive nature of diagnostic testing in medical care, there is increasing interest in reducing "low-value" testing.[1] Global definitions of low value testing tend to be subjective and difficult to apply to complex health systems. In addition, evidence based diagnostic testing may allow for the best care at a population level, yet may not be optimal for individual patients. Given this, taking patient preferences into account may help to better tailor care for individuals.[2]

Health insurance has been evolving in the U.S. with numerous recent policy changes. In general, patients are being asked to pay a larger proportion of their health care costs. Increasingly, clinicians are encouraged to involve patients in discussions regarding the value of health care options. Shared decision making potentially allows patient values, goals and preferences to be reflected in the decision to agree to a diagnostic test. Currently, these discussions are challenging as the costs and benefits of tests are often difficult to define or even estimate.[1,3]

The current investigation aims to estimate the individual level trade-offs between the benefits, risks, and cost of a diagnostic test within hypothetical acute medical conditions commonly seen in an emergency department. We hypothesized that a patient's willingness to undergo a diagnostic test is associated with different levels of potential benefit, risk, and the out-of-pocket cost of this test.

Methods

Overview

This is a cross-sectional survey of the effect of varying levels of risk, benefit, and cost of diagnostic testing on the probability of agreeing to pursue testing in two hypothetical clinical scenarios among adult patients in the University of Michigan Emergency Department (ED).

Study design

Participants were presented with two hypothetical clinical scenarios, in random order, in which they present to the ED with either low-risk chest pain (CP) or minor traumatic brain injury (mTBI). A subset of the mTBI respondents with children under the age of 18 were given a similar scenario in which their child was the patient (mTBI-child) instead of themselves (mTBI-adult).

Participants responded to both clinical scenarios and were randomly assigned to scenarios that described that risk as 0.1% or 1%; a benefit of 0.1% or 1%; and a cost of $0 or $100 for the diagnostic test. All eight combinations were given; in each benefit and risk could be equal or unequal. Different combinations of benefit, risk and cost could be presented to one individual for the chest pain and mTBI scenarios. These values were chosen to maximize the sensitivity of the study to detect differences in patient preferences based on a preliminary study performed by the authors, where we believed the most interesting zone of variation in patients' desire for diagnostic testing was for risk and benefit levels of 0.1% and 1% and cost levels of $0 and $100.[4] Additionally, risk values of 0.1% and 1% were felt to represent a realistic chance of developing cancer from diagnostic testing with radiation.[5] In order to improve participants' incorporation of numerical values into their decision-making, patients were presented with both textual and graphical representations where risk and benefit values were presented as a ratio and percentage, as well as with a pictograph representing values of 1 in 100 and 1 in 1000.[6] No graphical representation of money was employed.

A structured survey was then administered in which participants were asked to decide if they would pursue diagnostic testing given different levels of risk (the development of cancer within ten years due to ionizing radiation from the test), benefit (the chance of having an accurate diagnosis of disease requiring medical intervention), and cost (an additional test-specific copay) associated with the diagnostic test. Prior to launch, we used this survey in a prior, online only study.[4] In addition, we pilot tested the questions amongst adults associated with the study team. The survey was read aloud to all patients to reduce any misunderstandings caused by difficulties with reading or seeing. The full transcript of the scenarios and survey is available in the online supplementary material.

Setting and Participants

A convenience sample of adult patients who presented to the University of Michigan ED during daytime hours in June, July and August 2015 were recruited in the study until 900 completed surveys were achieved. Patients presenting with chest pain or recent head injury were not recruited so as to not interfere with their clinical course. Additionally, patients who were under contact precautions or in resuscitation bays were not approached. No compensation was offered for completion and participation was completely voluntary.

Variables: Data Sources and Measurement

The primary outcome was the number of patients who desired the diagnostic test in each of the two hypothetical scenarios. Risk, benefit, and cost of diagnostic testing were the main predictive variables. Potential confounders included age, gender, race, ethnicity, marital status, highest level of education, household income, if they were a medical professional, as well as past medical history of cancer, hypertension, diabetes, atrial fibrillation, and myocardial infarction, and self-reported overall health. We used a standardized data collection form through Qualtrics (online supplement reference).

Statistical Analysis

Study size

We surveyed 900 patients to ensure that we had at least 100 patients within each of the eight study arms (from the 2X2X2 study arm with two levels of the three key factors: risk, benefit, and cost). For each of the major comparisons (i.e. cost $0 versus $100), a total sample size of 900 provided approximately 86% power to detect a change in the proportion choosing a test from 50% to 60% with an alpha of 0.05. In addition, to ensure that our logistic regression model was not over-parameterized, we limited the fully adjusted model to 30 variables based on a predicted 300 outcome events (given a 33% event rate from our prior work and 900 subjects in the current study) and according to the guideline of 10 events per predictor for construction of logistic regression models.[4,7] We did not have a formal main statistical hypothesis and did not have a pre-specified belief regarding the relative importance of risk, benefit, and cost.

Analysis

All administered surveys in which the primary outcome was completed were analyzed. The unadjusted proportion of respondents who desired diagnostic testing for each level of risk, benefit, and cost were compared for the CP and mTBI scenarios. For proportions and differences in proportions, 95% confidence intervals were calculated using the normal approximation. A series of nested multivariable logistic regression models were then fit to predict the adjusted odds of desiring diagnostic testing for the CP and mTBI scenarios. We present odds ratios along with 95% confidence intervals for the predictors in the models. We considered three sets of variables to adjust for in the models, first simply looking at cost, risk and benefit in a single model; second adding in demographic factors; and third adding in variables regarding personal experience with health care. We specified all of these sets of variables in advance based on our belief on potential confounders from the perspective of clinical experience and scientific plausibility. Model 1 provided estimates for the cost, benefit, and risk of testing simultaneously. Model 2 included everything from Model 1, and further adjusted for demographic variables including age, gender, race, ethnicity, marital status, education, and income. Model 3 included everything from Model 2, and further adjusted for variables associated with a participant's experience with health care decision making, including working in the medical or health field, personal history of cancer, high blood pressure, diabetes, atrial fibrillation, and myocardial infarction, as well as self-reported overall health status. A subgroup analysis of respondents who were asked to decide about diagnostic testing for their child versus themselves in the mTBI scenario was conducted using the same statistical techniques. As this was an exploratory, observational study, no adjustments for multiple comparisons were made.

Results

Among the 928 patients who met inclusion criteria and were administered the survey, 28 were excluded for failure to complete the primary outcome portion of the survey. Results from the remaining 900 patients were included in the study and analysis. The mean participant age was 46.4 (SD 17.0). Additional participant characteristics reflect the demographics of a large suburban ED (Table 1).

Overall, participants elected to have diagnostic testing 68.2% of the time, including 69.7% of CP and 66.7% of all mTBI scenarios. In the unadjusted analysis (Table 2), increased cost and decreased benefit of testing were associated with decreased desire for diagnostic testing among adults responding for themselves in both CP and mTBI scenarios, though this did not reach significance for test benefit in the mTBI-adult scenario. For example, desired testing fell from 80.8% to 58.7% in the chest pain scenario when comparing the free versus $100 testing situations; the absolute difference in proportions was 22% (95% CI 16.1 to 27.7%); a similar magnitude drop of 17.4% (95% CI 10.5 to 24%) was observed in the mTBI-adult scenario. The risk of diagnostic testing was not associated with desire for testing in either the CP or mTBI-adult scenarios. Among mTBI scenarios, parents were significantly more likely to desire testing for their children than themselves at almost all levels of risk, benefit, and cost. This difference was most pronounced for higher-cost testing, which was desired 30.2% (95% CI 17.8%-38.6%) more often for their children than for themselves, and least pronounced for free testing, which was the only instance where parents' desire for testing of their children was not significantly higher than for themselves (difference 8.2%; 95% CI -3.4% to 17.1%). Furthermore, parents' desire for diagnostic testing of their children was not significantly associated with risk, benefit, or cost.

The pattern of desire for diagnostic testing in the adjusted regression models was similar to the unadjusted analysis, with increased cost and decreased benefit being associated with decreased desire for diagnostic testing among adults responding for themselves. Furthermore, there were no substantial changes in the odds of the primary outcome after fully adjusting for demographics and experience with medical decisions (Table 3), suggesting that the relationship between desire for diagnostic testing and the benefits, risks, and cost of testing are not confounded these variables.

In the fully adjusted models (Table 3), the odds of an adult desiring diagnostic testing for him or herself are lower when testing costs $100 compared to $0; for both chest pain: adjusted odds ratio (AOR) 0.33 (95% CI 0.23 to 0.47) and adult mTBI: AOR 0.47(95% CI 0.33 to 0.67). In addition, we observed higher odds of desired testing when the benefit of testing increased from 0.1% to 1.0% for the CP scenarios: AOR 1.67 (95% CI 1.18 – 2.35). This did not reach significance for test benefit in the mTBI-adult scenario.

The fully adjusted models of desire for testing in each clinical scenario (eTables 1-4) demonstrated that patients over the age of 65 are significantly less likely to desire testing for CP compared to patients less than 35 years old (AOR 0.49; 95% CI 0.25 – 0.94). College graduates are the most likely to desire testing for both CP and mTBI, and more than twice as likely than those with some high school education (AOR 2.12, 95% CI 1.07-4.21). Participants who earned less than $25,000 per year were significantly less likely to desire testing for CP (but not mTBI) than almost all other income brackets, even after controlling for cost. Physicians, pharmacists and nurses are significantly less likely to desire diagnostic testing for themselves when compared to non-medical professionals and other ancillary medical staff when presented with the mTBI-adult scenario but not the CP or the mTBI-child scenarios.

Discussion

This study evaluated the relationship between risk, benefit, and cost of diagnostic testing on patient preferences for pursuing low-value testing the ED. In this cross-sectional convenience sample, we found that the cost and potential benefits of a radiologic diagnostic test play an important role in patients' preferences for pursuing diagnostic testing. Interestingly, the risk of the test was not significantly associated with the odds of pursuing testing. This work is hypothesis generating. There are some potential implications of payers and patients. An additional $100 patient required contribution to the testing tended to decrease desire for testing from about 80% to about 60%. In addition, the implication for practicing emergency physicians is as follows – increasing the risk of a diagnostic test did not seem to diminish the patient desire for the test therefore discussion regarding testing that involve risk may not influence patient desires, at least in the low probability space of testing risk of 1% and less.

One explanation for why risk was not a significant factor could be that the difference between 0.1% to 1% represents an insignificant increase in risk to our respondents. However, this same increase in benefit did show a significant effect. Another possibility is that patients care more about their immediate needs, such as the chance of finding an underlying condition and how much it will cost them, and less about the future risk of developing cancer. Additionally, many patients may associate brain bleeds and heart disease, but not necessarily cancer, with definite or immediate mortality and morbidity. They may view the presented scenario as a choice between the immediate risk of certain death or disability against the possibility of a treatable illness in the distant future.

Interestingly, patients appear to hold different values regarding diagnostic testing for their children than they hold for themselves. Those who were presented with the mTBI scenario for their child pursued diagnostic testing more frequently than for themselves regardless of the level of benefit, risk, or cost. While this study lacked the statistical power to draw major conclusions about the pediatric scenario, further research may uncover interesting results about how parents make healthcare decisions for their children as opposed to for themselves.

These relationships of benefit, risk, and cost were not affected by any confounding factors that we measured. There were however some subgroups which behaved slightly differently, but these did not affect the overall results (eTables 1-4). Notably, healthcare providers desired testing less often for the mTBI scenario but not the chest pain scenario. This is likely explained by the decreased prevalence of major intracranial bleeding in TBI patients with a benign exam versus a reasonably high prevalence of coronary artery disease in the population of patients with chest pain. Another interesting outlier is the lowest income group (less than $25,000), which was the only income subgroup that generally declined testing, even when they were told it would be free to them. This study was not designed to evaluate subtleties between demographic groups but it is an interesting finding nonetheless.

Increasing the cost of the diagnostic test from $0 to $100 was associated with a 3 fold decreased odds of pursuing diagnostic testing. This implies that the cost of care is a major factor patients consider, and may be used to discourage low-value testing through test-specific copayments, although this may also discourage reasonable testing as well. Medicare reimbursements are increasingly becoming tied to patient satisfaction, which is associated with patients receiving the tests they believe they need.[8,9] Further investigations could explore whether individual financial incentives prevent low-risk patients from seeking wasteful testing to the same degree as charging patients a fee for the test.

There are a few key limitations to consider when interpreting the results of our study. First, this study asked participants to imagine a hypothetical situation that is subject to limitations of imagination. It is likely more difficult for patients to consider the distant risk of developing cancer when also contemplating a potential myocardial infarction or brain hemorrhage. This reflects the well-known human behavior of time discounting. Second, respondents may have had difficulty fully embracing the risks and benefits that were given to them, largely since they had difficulty believing their own real-life comorbidities and risk factors were properly accounted for in the scenario despite the design emphasizing they were. As an example, some patients on anticoagulation have been instructed to always get a head CT scan if they fall and they may have been assigned to the 0.1% risk category in our study. Third, many patients may also have struggled with interpreting percentages, despite the use of visual aids. Fourth, this study limits the risk of a test to the probability of developing cancer in the future secondary to radiation and this is an oversimplification of a very complex issue. In reality, the risks of diagnostic tests are highly variable, and assessing their numerical risk is challenging. The scenarios we utilized were emergent situations, and they helped expose patients' underlying values regarding the risks, benefits, and costs of diagnostic testing. While these findings could theoretically be generalized to other situations of risk, benefit, and cost, our study was specifically restricted to low-benefit and low-risk situations regarding diagnostic radiologic testing in the emergency department. The above relationships may vary significantly in different contexts or at different levels of benefit, risk, and cost. Next, the mTBI-child group was under-powered to demonstrate any associations between risk, benefit, and cost with desire for diagnostic testing. Fifth, we did not assess numeracy using a validated scale, but instead used pictographs – a method considered to be one of the best methods of communication for those with low numeracy.[10] Sixth, the patient was not experiencing the acute uncertainty and potential anxiety of chest pain or a head injury and as such willingness to undergo testing may be different. Finally, this study did not utilize a true shared decision making model where the physician and the patient discuss the risks and benefits and then make a choice together. Rather, this study assumed the physician could calculate the risk and benefit with 100% accuracy and then forced the patient to decide on their own in essentially a reverse paternalistic model. Future work could consider adding in provider uncertainty regarding benefits and risks possibly by adding ranges (i.e. "your risk of a brain bleed is between 1 in 1000 and 1 in 10,000") with pictographic supporting materials.

Conclusions

This cross-sectional survey suggests that patient preferences for diagnostic testing differ based on the cost and benefits of testing, but that long-term risks may play a smaller role. Additionally, finances seemed to be a major motivating factor for patients to avoid testing. With patients having a growing personal contribution to healthcare, this impact should be studied further to determine how best to implement financial considerations to alter testing behavior. This study utilized a copay to 'penalize' for the test, however, a credit for foregoing the test similar to a safe driver discount would be an interesting direction for future research.

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Tables and Figures:

Tables:

Table 1: Characteristics of survey participants (N=900)

Characteristic	**No. (%)**
Age, years (n=898)	
<= 35	271 (30.2)
35 - 49	226 (25.2)
50 - 64	258 (28.7)
>= 65	143 (15.9)
Male (n=897)	449 (50.1)
Race (n=892)	
Caucasian	663 (74.3)
African American	150 (16.8)
Asian	46 (5.2)
Other	33 (3.7)
Hispanic (n=890)	46 (5.2)
Marital Status (n=895)	
Married	429 (47.9)
Single/never married	294 (32.9)
Previously married	172 (19.2)
Have children under 18	267 (29.7)
Highest level of Education (n=892)	
Some high school	79 (8.9)
High school graduate	184 (20.6)
Some college	266 (29.8)
College graduate	252 (28.3)
Post-graduate	111 (12.4)
Household income level (n=756)	
Less than $25,000	267 (35.3)
$25,000 - 49,999	171 (22.6)
$50,000 – 74,999	113 (15)
$75,000 – 99,999	62 (8.2)
$100,000 – 149,000	91 (12)
$150,000 or more	52 (6.9)
Healthcare professional (n=893)	

No	659 (73.8)
Practitioner	72 (8.1)
Ancillary staff (not directly involved in clinical decision making)	162 (18.1)
Past medical history	
History of cancer (n=895)	162 (18.1)
History of diabetes (n=894)	167 (18.7)
History of hypertension (n=894)	298 (33.3)
History of atrial fibrillation (n=894)	64 (7.2)
History of heart attack (n=894)	47 (5.3)
Overall health (n=893)	
Poor	112 (12.5)
Fair	224 (25.1)
Good	298 (33.4)
Very good	203 (22.7)
Excellent	56 (6.3)

Table 2: Testing preferences across varying levels of risk, benefit, and cost for each scenario

	CP (n=900) Number desiring testing / Number randomized to group (%)	**mTBI-adult (n=775)** Number desiring testing / Number randomized to group (%)	**mTBI-child (n=125)** Number desiring testing / Number randomized to group (%)	Difference between percent desiring testing among mTBI-child and mTBI-adult (95% CI)
Risk				
0.1%	319/453 (70.4)	249/380 (65.5)	63/72 (87.5)	22.0% (11.3% to 29.6%)
1%	308/447 (68.9)	247/395 (62.5)	41/53 (77.4)	14.8% (1.1% to 25.2%)
Diff. (95% CI)	-1.5% (-7.5% to 4.5%)	-3.0% (-9.7% to 3.8%)	-10.1% (-24.3% to 3.1%)	
Benefit				
0.1%	291/448 (65.0)	228/375 (60.8)	59/72 (81.9)	21.1% (9.7% to 29.9%)
1%	336/452 (74.3)	268/400 (67.0)	45/53 (84.9)	17.9% (5.2% to 26.6%)
Diff. (95% CI)	+9.4% (3.4% to 15.3%)	+6.2% (-0.6% to 12.9%)	+3.0% (-11.0% to 15.7%)	
Cost				
$0	361/447 (80.8)	275/377 (72.9)	56/69 (81.2)	8.2% (-3.4% to 17.1%)
$100	266/453 (58.7)	221/398 (55.5)	48/56 (85.7)	30.2% (17.8% to 38.6%)
Diff. (95% CI)	-22.0% (-27.7% to -16.1%)	-17.4% (-24.1% to -10.5%)	+4.6% (-9.1% to 18.3%)	

Total	627/900 (69.7)	496/775 (64.0)	104/125 (83.2)	

Table 2 caption: Proportions are unadjusted. Abbreviations: CP = chest pain, mTBI = mild traumatic brain injury, diff = difference, CI = confidence interval.

Table 3: Associations between testing risk, benefit and cost: logistic regression models

	Model 1 AOR (95% CI)	Model 2 AOR (95% CI)	Model 3 AOR (95% CI)
CP (n=900)			
Risk (1% v. 0.1%)	1.01 (0.75, 1.36)	0.99 (0.71, 1.39)	0.98 (0.70, 1.38)
Benefit (1% v. 0.1%)	1.55 (1.15, 2.08)	1.63 (1.16, 2.29)	1.67 (1.18, 2.35)
Cost ($100 v. $0)	0.34 (0.25, 0.46)	0.34 (0.24, 0.48)	0.33 (0.23, 0.47)
mTBI all (n=900)			
Risk (1% v. 0.1%)	0.80 (0.60, 1.06)	0.82 (0.60, 1.13)	0.82 (0.60, 1.14)
Benefit (1% v. 0.1%)	1.30 (0.98, 1.73)	1.24 (0.90, 1.71)	1.27 (0.92, 1.76)
Cost ($100 v. $0)	0.50 (0.37, 0.66)	0.53 (0.39, 0.73)	0.50 (0.36, 0.69)
mTBI adult (n=775)			
Risk (1% v. 0.1%)	0.86 (0.64, 1.16)	0.87 (0.62, 1.21)	0.86 (0.61, 1.20)
Benefit (1% v. 0.1%)	1.35 (0.999, 1.82)	1.26 (0.90, 1.77)	1.28 (0.90, 1.80)
Cost ($100 v. $0)	0.46 (0.34, 0.62)	0.50 (0.36, 0.71)	0.47 (0.33, 0.67)
mTBI child (n=125)			
Risk (1% v. 0.1%)	0.48 (0.19, 1.26)	0.51 (0.12, 2.16)	1.75 (0.19, 16.53)
Benefit (1% v. 0.1%)	1.08 (0.40, 2.94)	0.73 (0.16, 3.44)	1.02 (0.07, 16.00)
Cost ($100 v. $0)	1.42 (0.52, 3.85)	1.09 (0.26, 4.49)	2.19 (0.20, 23.42)

Table 3 Caption: Nested logistic regression models of the odds of electing diagnostic testing among emergency department patients presented with hypothetical clinical scenarios of chest pain and minor traumatic brain injury. Model 1 accounts only for risk, benefit and cost simultaneously. Model 2 adds demographic variables including age, gender, race, ethnicity, marital status, education, and income. Model 3 additionally includes working in the medical or health field, personal history of cancer, high blood pressure, diabetes, atrial fibrillation, and myocardial infarction, as well as self-reported overall health status. Abbreviations: CP = chest pain, mTBI = mild traumatic brain injury, AOR = adjusted odds ratio, CI = confidence interval.